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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY—Circular No. 3.
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SOME STEM TUMORS OR KNOTS ON APPLE AND QUINCE TREES.

BY
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Investigations of Diseases of Fruits.

GOVERNMENT PRINTING OFFICE WASHINGTON 19

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SOME STEM TUMORS OR KNOTS ON APPLE AND QUINCE TREES.[a]

OCCURRENCE OF TUMORS.

A peculiar form of tumors or knots has been observed by the writer during the past five years occurring on the trunks, limbs, and twigs of apple trees (fig. 1) and quince trees (fig. 2) in a number of localities in various portions of the United States. These localities are in some cases widely separated, indicating that the disease may be found occurring over a wide extent of territory. The tumors on the quince have been observed at Chico and other points in California, and reports of their occurrence, with specimens, have been received by the writer from Ansted, W. Va. Those on the apple have been noted in a number of localities in California, Oregon, New Mexico, Texas, Arkansas, Kansas, Nebraska, Iowa, Missouri, Illinois, and West Virginia. Specimens taken from apple seedling trees have been received from Mr. C. G. Woodbury, of the Indiana Agricultural Experiment Station, collected in southern Indiana.

Garcia, of the New Mexico Experiment Station, reports the disease on apple trees from Mesilla Park, Hatch, and Garfield, N. Mex. Garman,[b] of the Kentucky Experiment Station, has described a form

[a] This paper records the results of observations and experiments on a type of disease that occurs in the apple and quince orchards and is particularly troublesome to nurserymen. The tumors described are related to hairy-root and crown-gall, and this publication summarizes a part of an extensive investigation which Doctor Hedgcock is pursuing on the crown-gall and related diseases. The paper brings out some important facts regarding the relation of the knots above ground to certain forms of hairy-root, and contains advice to nurserymen as to how to avoid the trouble. These investigations were begun at the Mississippi Valley Laboratory, St. Louis, Mo., under the direction of Doctor Hermann von Schrenk, and will be continued under the direction of Mr. M. B. Waite, Pathologist in Charge of Investigations of Diseases of Fruits. B. T. Galloway, *Pathologist and Physiologist, and Chief of Bureau.*

[b] Garman, H. Diseases of Nursery Stock.—A Knot Disease of Apple Trees. Kentucky Agricultural Experiment Station, Bulletin 93, pp. 106-107 and fig. 4, 1901.

[Cir. 3]

of knots occurring on apple trees which is apparently the same disease; this he reports from at least two localities in the State.

FIG. 1.—Stem tumors on an old apple tree at Mesilla Park, N. Mex.

Waite, of the Bureau of Plant Industry, reports the disease as common on the apple in tidewater Maryland and Virginia.

DESCRIPTION.

On the apple tree this disease appears most often on the trunk and larger limbs (fig. 1), but in a number of instances it has been found

affecting the twigs and smaller limbs (fig. 3). A good example of the disease as found on all parts of the tree occurs on a Charlamoff apple tree in the experimental orchard of the Arkansas Agricultural Experiment Station, Fayetteville, Ark. This was first reported to the Bureau of Plant Industry by Vincenheller, of that station, who kindly donated the tree to the Department of Agriculture for further

FIG. 2.—Stem tumors on a Meech quince tree at Chico, Cal.

study. The progress of the disease on this tree has been noted for three successive years.

The tumors on this tree are exceptionally large at the beginning, and frequently appear in the form of a smooth swelling surrounding the base of a dormant bud (fig. 3), quite often the terminal bud of

a twig, and may be noted at the end of the growing season. In the form usually occurring on many other trees, the swellings appear on twigs and limbs indiscriminately, apparently having no connection with the formation of buds. The tumors vary greatly in size on the same and on different trees; some are as small as a pea; others attain a size of 2 to 3 inches in diameter. This variation in size is noted even at the beginning of the formation. Immature tumors are often formed on all portions of the tree, quite frequently occurring at the base of twigs (fig. 3) or springing from older limbs or from the trunk. During the first period of their growth the swellings are covered with a thick, fleshy layer of meristem and bark tissues. The growth for the first year or two is often very rapid. At the end of a varying period of time, usually one to three years, depending on the variety of the tree and the conditions of growth in the locality where it is found, the bark covering the tumors becomes ruptured by the rapid formation in the interior of a very peculiar structure; the bark tissue ceases to grow, but the interior tissues develop a structure similar to that found in root formation in the hairy-root disease. As the bark breaks away, small elevations, which resemble short thickened root caps, appear on the surface of the tumors, giving them a very warty appearance (fig. 4). The knots now resemble the origin of the formation of the woolly-knot form of hairy-root described by the writer[a] in a lecture to the National Nurserymen's Association last year.

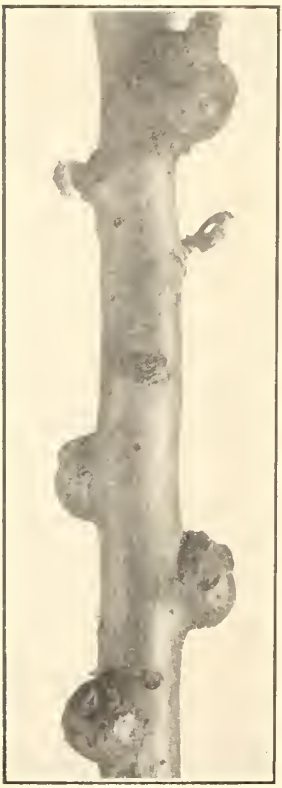

FIG. 3.—Young tumors forming at the base of twigs on a Charlamoff apple tree at Fayetteville, Ark.

The tumors in their older form in some cases become hollowed out by a slight decay of the tissue in the center, which results either directly from the disease or from the entrance of wood-rotting organisms which are foreign to it. The mature form of these knots (fig. 1) resembles greatly the outgrowths upon the limbs of a number of kinds of trees described by Sorauer[b] in Germany under the

[a] Hedgcock, George G. Prevention of Apple Crown-Gall and Hairy-Root. National Nurseryman, vol. 15, pp. 192–193, 1907. American Fruits, vol. 7, p. 69, 1907. Apple Specialist, vol. 4, pp. 11–15, 1907.

[b] Sorauer, P. Kropfmaser. Handbuch der Pflanzenkrankheiten, vol. 1, pp. 731–731 and fig. 38, 1886.

name of Kropfmaser, with which form of disease they may be identical. A similar form on *Pirus malus chinensis* has been described by Kissa.[a]

On the quince tree the disease originates quite similarly to that already described on the apple tree, with the exception that tumors have not been noted affecting the end and base of small twigs. The disease appears first in the form of small swellings on various portions of the limbs and twigs of the trees. In a year or two the fleshy bark of these is broken open by the formation of numerous root-like structures, and the tumors assume a black, roughened appearance, but resemble greatly in structure the older forms described on the apple tree. These peculiar outgrowths (fig. 2) are often very numerous on the limbs and trunks of quince trees.

FIG. 4.—Older tumors than those shown in figure 3 on a Charlamoff apple tree at Fayetteville, Ark.

EXPERIMENTS.

A number of limbs diseased similarly to those shown in figure 2 were taken from quince trees at Chico, Cal., and others similar to those shown in figures 1, 3, and 4 were taken from an apple tree at Fayetteville, Ark., and entirely covered with moist soil at the Missouri Botanical Garden, St. Louis, Mo., during the month of March, 1906. After these had been covered with moist soil for about four weeks they were taken out, and a number of the tumors had produced roots in abundance from the surface (figs. 5 and 6), but no roots were thrown out from any other portion of the limbs. In the case of the apple limbs each of these knots, after they had developed roots from 1 to 2 inches in length from further growth in the soil, agreed in appearance and structure with the knots occurring in connection with one form of the hairy-root disease of the apple, known as the woolly-knot form (see fig. 9).

In February, 1907, scions were taken from the Charlamoff tree previously mentioned, some of which contained knots or tumors like those

[a] Kissa, N. W. Kropfmaserbildung bei Pirus malus chinensis. Zeitschrift für Pflanzenkrankheiten, vol. 10, pp. 129–132 and 2 plates, 1900.

shown in figure 3, while others were smooth and apparently healthy. About 70 per cent contained no knots or tumors; these were grafted on piece roots from healthy apple seedlings. One hundred of these grafts were planted and grown on the Potomac Flats, near Washington, D. C. The trees grown from these were dug at the end of the season, and 69.3 per cent were found to be diseased to a greater or

FIG. 5.—Roots produced from a tumor on a cutting taken from a Charlamoff apple tree and kept in moist soil.

FIG. 6.—Roots produced from tumors on a cutting taken from a Meech quince tree near Chico, Cal.

less degree with the woolly-knot form of the hairy-root disease. The remaining trees were apparently healthy, having smooth roots. Those scions which had tumors before planting developed in nearly every instance roots from the tumors, which then agreed in structure and appearance with the woolly-knot form of hairy-root.

STRUCTURE OF TUMORS.

If a section is made longitudinally through one of the tumors taken from the limb of an apple tree after roots have been forced from it by moisture (fig. 7) and through one of the underground rooted tumors of the woolly-knot form of hairy-root (fig. 8), an identical structure is revealed. The wood elements of both are much distorted and disarranged, growing somewhat in a fan shape from the origin of the tumors near the center of the stem or root. The

bundles of woody tissue are mingled abnormally with small patches of parenchymatous tissue. Springing from the surface of each of

FIG. 7.—Longitudinal section of a tumor on an apple limb after throwing out roots when placed in soil.

FIG. 8.—Longitudinal section of woolly-knot on a root-grafted apple tree grown from apparently healthy scion and root.

these forms are numerous fleshy roots which are often fasciated and distorted. These fleshy roots as they grow older either rot away in part or become woody.

RELATION OF THE TUMORS TO OTHER FORMS OF DISEASE.

With our present knowledge, therefore, and as a result of the observations and experiments previously mentioned, these tumors on the limbs and trunks of apple trees may be considered the same disease as the woolly-knot form (fig. 9) of hairy-root; in other words, they are the aerial form of hairy-root. The simple form of hairy-root, which was described first by Stewart, Rolfs, and Hall[a] and mentioned later by the writer[b] as a form of disease distinctly different

[a] Stewart, F. C., Rolfs, F. M., and Hall, F. H. Geneva, N. Y., Agricultural Experiment Station Bulletin 191, pp. 300–301 and pl. 2, 1900; also Geneva, N. Y., Agricultural Experiment Station Report 19, pp. 176–178 and pl. 23, 1901.

[b] Hedgcock, George G. The Crown-Gall and Hairy Root Diseases of the Apple Tree. Bureau of Plant Industry Bulletin No. 90, Part II, pl. 2, fig. 1, and pl. 3, fig. 2, 1905.

from crown-gall, is in the opinion of the writer only a form of the same disease as woolly-knot and these aerial tumors. The simple form of hairy-root occurs most frequently upon seedling trees; it is present both on the stem and root portions of the trees. It consists, when it occurs on the roots, of numerous fine roots growing at right angles from the main roots or the taproot (fig. 10). These side roots are very soft and succulent at first, but later harden and have a wiry appearance and texture. On the roots they are usually quite uniformly distributed in definite belts. Where this form occurs on shoots it springs more frequently from the vicinity of a bud (fig. 11), often just beneath it. These fine roots are formed in groups, or bunches, a great many often springing from a single origin. The origin of each of these clumps of roots is similar to that of the rudimentary roots in the aerial tumors. It follows, then, that the hairy-root disease may have at least three forms, which are more or less distinct: The simple, the woolly-knot, and the aerial forms.

FIG. 9.—The woolly-knot form of hairy-root on a Northern Spy apple tree grown in an experiment.

EFFECT OF THE DISEASE UPON TREES.

Owing to the complexity in the forms of the hairy-root disease and the difficulty of obtaining accurate information as to their final effect upon orchard trees, and in view of the fact that extensive experiments are being conducted to determine the nature of each form and its effect upon the life and fruitfulness of apple trees, it will not be safe at present to make a definite statement as to the effect of these tumors further than to give the observations of the writer.

Apple trees from fifteen to twenty years old badly diseased with these tumors have been observed in various localities in the Mississippi Valley. The cores of the tumors extended nearly to the heart or center of the wood of the largest limbs, indicating that the tumors had been present during the lifetime of the trees. Upon inquiry, the owners claimed that such trees usually bore as well as other trees in the orchard, and from all indications they were making as good growth as other trees. The knots were apparently sound throughout, and as far as could be observed did no damage to the tree other than to obstruct the circulation to some extent. This interference with the circulation of the tree, however, can not be considered beneficial to its growth.

FIG. 10. The simple form of hairy root on an apple seedling grown in an experiment.

Waite, of the Bureau of Plant Industry, has observed in many instances that the centers of old tumors on mature apple trees often decay, either directly as a result of this disease or through the entrance of organisms which may seriously injure the tree. The climate and conditions of the Atlantic coast, where Waite made his observations, are different from those in which the writer's observations were made, and this may account in some measure for the different effect observed.

FIG. 11.—The origin of hairy-root from buds on an apple seedling.

A study of the effects of the forms of the disease occurring on the roots of the apple tree is in progress and it is hoped that the results may be published later. Some of these results are very peculiar; for instance, the writer was surprised to find, in planting out in an orchard under the same conditions during a very dry season about 700 apple trees, one half of which had roots diseased with hairy-root of the woolly-knot type (fig. 9) and the other half healthy, smooth roots, that a greater stand of trees was obtained with the former. The loss in the case of the hairy-root trees was about 19 per cent.

and of the trees with smooth roots about 32 per cent. This may be accounted for in part by the increased tendency to throw out roots in the case of the trees diseased with hairy-root.

This peculiar behavior on the part of trees diseased with hairy-root is further explained by another experiment. Since apple trees are propagated commercially by grafting and budding, never by cuttings, because they root so rarely, it was a surprise to find that cuttings from trees with hairy-root are often able to throw out roots readily. In an experiment where 100 cuttings were taken from the shoots of yearling seedlings badly diseased with the simple form of hairy-root (fig. 10) and planted in moist soil in the greenhouse in early spring, more than 50 per cent rooted readily and 25 per cent grew into trees. On the other hand, out of 100 cuttings taken from healthy seedlings of the same lot, only 5 per cent rooted, and even then so feebly that none of them grew into trees. This experiment was carried out on an ordinary greenhouse bench with 8 inches of soil, without bottom heat.

Some of the diseased quince trees observed by the writer in California were much stunted in their growth, but were considered a profitable investment by the owner on account of the crops of fruit which they had borne for several years. The quince trees in California appear to be quite universally affected with this disease, though usually with only a mild form. No indication has been found that the disease spreads in the orchard from one tree to another, either in the case of apple or quince trees, and experiments in which inoculations were made with chips from living tumors indicate that it is either very little or not at all contagious. In the case of apple trees, the percentage of disease on the roots of trees in nursery rows increases perceptibly from the first to the second year and remains the same or decreases from the second to the third year. This observation is based upon an extensive experiment.

It might easily be true that a reasonable amount of this disease on a tree stimulates it and encourages fruit production. That it does stimulate root production and may temporarily stimulate the growth of the tree are facts now well known to the writer and have been observed in many instances in the case of nursery trees. The disease, therefore, appears to be not as injurious as one would think. It can hardly be possible, however, that in the long run trees seriously affected by this disease will not suffer. Branches badly affected, as shown in figures 1 and 2, certainly must have their movement of sap greatly impeded, their general activities much curtailed, and eventually their life shortened. It is not believed, however, that small tufts of hairy-roots on very limited areas of the root system of an apple tree will in any way perceptibly affect the growth and fruitfulness of an apple tree or decrease its length of life.

SUGGESTIONS TO NURSERYMEN, NURSERY INSPECTORS, AND ORCHARDISTS.

Nurserymen are advised to be careful in the selection of scions and stocks for propagation and to see that they are always taken from healthy trees. The experiments of the writer in the case of the apple indicate that all forms of hairy-root on scions increase where the scions are taken from diseased trees.

The following suggestions based upon experiments and observations are made to nursery inspectors: Apple or quince trees badly diseased with any of the forms of hairy-root, whether aerial, woolly-knot, or simple, should be discarded as unfit for planting. Figures 1, 2, 3, 4, 9, and 10 represent severe types of aerial, woolly-knot, and simple forms of hairy-root. The last two forms occur on the roots of trees in the nursery, while the first is found as a rule only on orchard trees, probably as a later development of the more intense forms of the disease on the roots.

If all trees affected with traces or milder forms of the disease as it occurs on the roots were discarded, it would mean the rejection of nearly all of the trees grown in some localities. Such trees when they have a vigorous root system, notwithstanding traces or mild forms of the disease, apparently grow as well as healthy trees with smooth roots, or in some cases may grow better for the first few years, so far as has been ascertained by experiments and observations. Until it can be shown that the presence of the milder forms of the disease on the roots of nursery trees will lead to its further spread in the orchard, or that such trees are unprofitable for planting, it does not seem justifiable to condemn them. On the other hand, the writer is not ready to assert that they are equally as good for planting as trees with smooth roots.

There is a difference of opinion as to what constitutes a healthy root system; some would limit the application of the term "healthy" to trees entirely free from fibrous root formation on the main roots. The writer has observed that trees with a very fibrous root system are often the product of certain kinds of soil and are apparently as healthy as trees more nearly free from such roots. Such trees are equally as good for planting as those with smooth roots and might easily be mistaken for diseased trees slightly affected with traces of hairy-root. Until it can be shown that fibrous roots are inferior to smooth roots and that the milder forms of hairy-root seriously affect orchard trees, the writer is not ready to recommend the destruction of such trees in the nursery, since this course would probably involve an unnecessary loss of many thousands of dollars to the nurserymen and a consequent increase in the price of trees to the orchardists.

Reports have been received from a number of localities where all the trees in orchards affected by these tumors (fig. 1) have been cut down on account of their presence. In the absence of data proving the disease to be seriously injurious and in view of the writer's observations, orchardists are advised for the present to allow such trees to remain in their orchards in cases where there is no apparent spread of the disease and where the trees are bearing profitable crops of fruit. If, on the other hand, the trees are not doing well as compared with healthy trees, it would be better to remove them.

REPORTS DESIRED ON THE DISTRIBUTION AND SEVERITY OF STEM TUMORS OR KNOTS.

It will readily be seen that further information as to the distribution and severity of this disease is needed. To this end it is proposed to visit as many localities as possible where outbreaks of the disease are reported.

All persons who have observed stem tumors or knots in orchards will confer a favor and will aid in accumulating data if they will report the localities where the disease occurs, with notes as to its severity. All communications should be addressed to the Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.

Approved:
JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *April 1, 1908.*

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